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Detailed description of modulation system for C62

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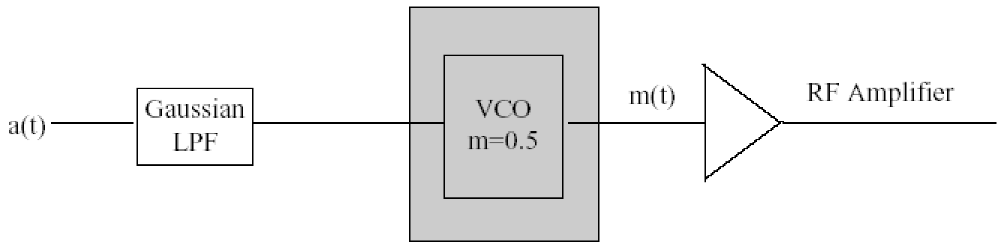
GLOSSARY

1 DETAILED DESCRIPTION OF MODULATION SYSTEM

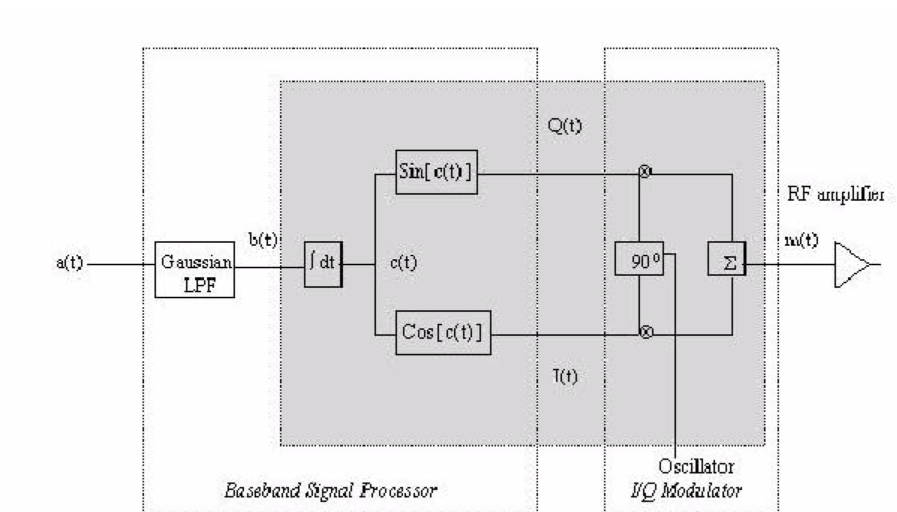
The following description of modulation system is taken directly from Appendix D Digital Modulation and GMSK –University of Hull

1.1 D5.1 GMSK Modulation

There are two methods to generate GMSK, one is frequency shift keyed modulation, the other is quadrature phase shift keyed modulation.



GMSK implemented by Frequency Shift Keying modulation with FM-VCO.



GMSK implemented by a quadrature baseband method.

The implementation in the second employs a quadrature baseband process followed by a quadrature modulator. With this implementation, the modulation index can be maintained at exactly 0.5. This method is also cheaper to implement.
Both methods lead to the same GMSK modulated signal.
We are going to be looking at the second of these two methods, that is we shall be looking at a quadrature baseband processor followed by a quadrature modulator as

shown in the second.

The Gaussian low-pass filter has an impulse response given by the following equation

$$g(t) = \frac{1}{2T}\ [Q(2\pi B_b \frac{t-T/2}{\sqrt{\ln 2}})-Q(2\pi B_b \frac{t+T/2}{\sqrt{\ln 2}})]$$

for

$$0 \leq B_b\, T \leq \infty$$

where Q(t) is the Q-function

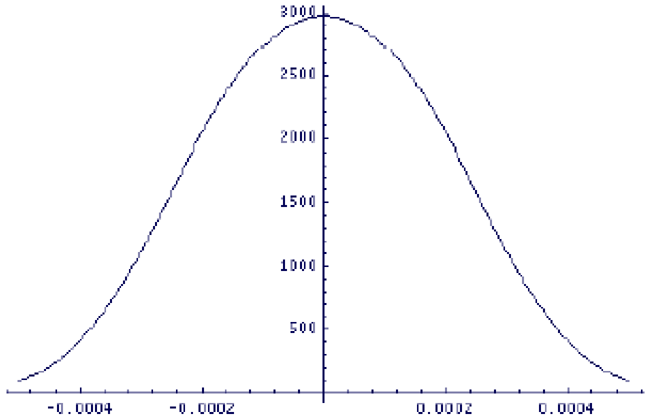
$$Q(t) = \int_t \frac{1}{\sqrt{2}} \exp(-x^2/2)\, dx\ ,$$

B_b is the bandwidth of the low pass filter having a Gaussian shaped spectrum, T is the bit period and BN=B_b T is the normalised bandwidth.

To demonstrate this, we are looking at a filter with a bandwidth of B_b =1000 and a bit rate of T=1/2000, i.e. a normalised bandwidth B_N=B_b.T =0.5.

The impulse response of the Gaussian low-pass filter has to be truncated and scaled, according to the B_N value, to ensure that the effect of a single 1 passing through the filter, is a phases change of $\pi/2$.

For a B_N of 0.5 the filter response is truncated, symmetrically around zero, to two bit periods, i.e. from -T to T. The truncated filter response is represented graphically in the following figure.



The truncated and scaled impulse response of the Gaussian low-pass filter.

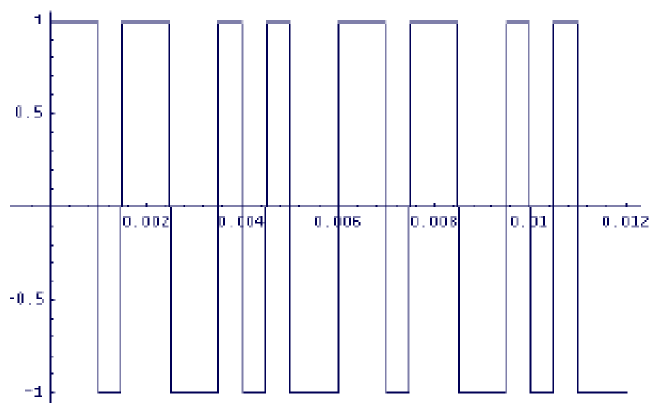
Ensuring that the response of the filter to a single 1 is a phase change of $\pi/2$, is equivalent to choosing the constant K to satisfy the following equation

$$\int_{-T}^{T} Kg(t)dt = \pi/2.$$

To demonstrate the modulation, we are using the following randomly chosen binary data stream. (This data stream repeats after 12 bits.)

{1,1,-1,1,1,-1,-1,1,-1,1,-1,-1, 1,1,-1,1,1,-1,-1,1,-1,1,-1,-1,............}.

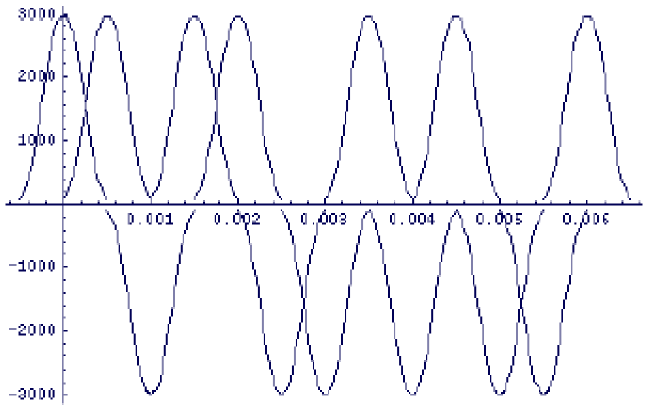
The beginning of this data stream can be represented graphically by the following



The beginning of the data stream being sent through the filter.

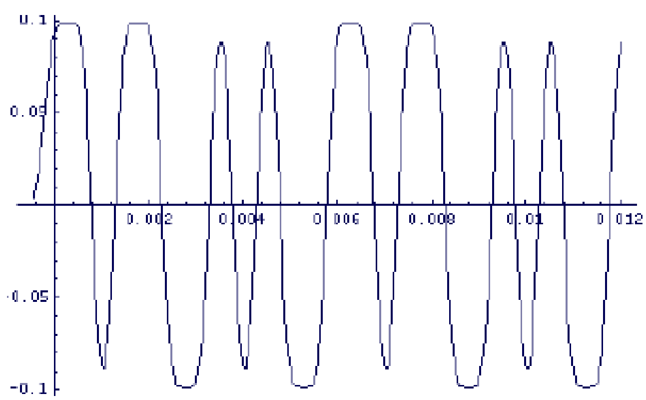
As the data passes through the filter it is shaped and ISI (inter symbol interference) is introduced since more than one bit is passing through the filter at any one time. For $B_N = 0.5$, since the bits are spread over two bit periods, the second bit enters the filte as the first is half way through, the third enters as the first leaves etc....

The first few Gaussian shaped pulses are represented graphically in the following figure.



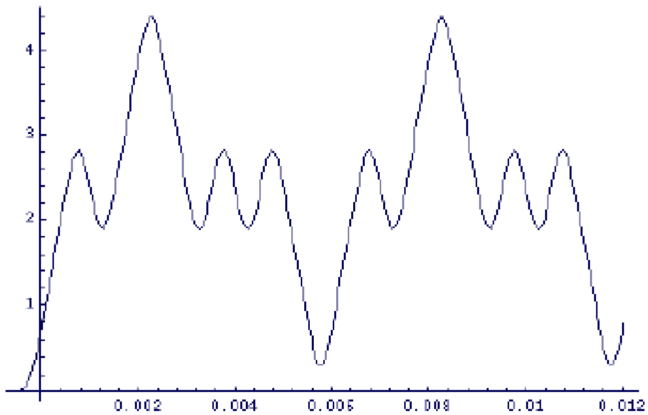
The individual shaped pulses representing the data stream.

These individual shaped pulses are then added together to give a function which is represented graphically in the following figure. This is the function denoted by b(t).



The function b(t) as in the second figure

This function, b(t), is then integrated, with respect to t (time) from t to ∞, to give the function c(t) as shown in the second figure. This function c(t) is represented graphically below.

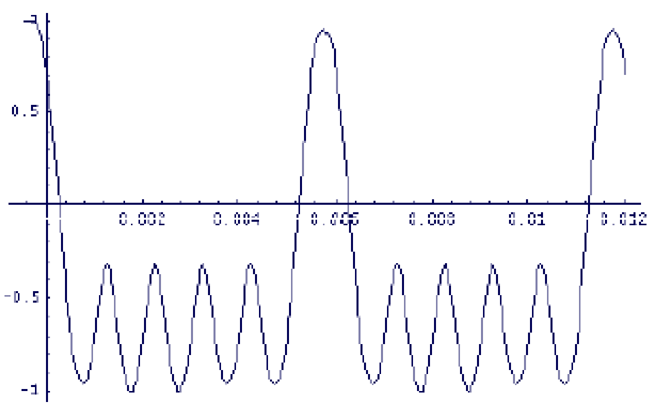


The function c(t) as in the second figure.

Once we have the function c(t), we take Sine and Cosine functions of it to produce the I and Q-baseband signals. Taking the Cosine of c(t) produces the I-baseband signal I(t) i.e.

$$I(t) = \text{Cos}[\ c(t)\ ].$$

This function I(t) is represented graphically below.

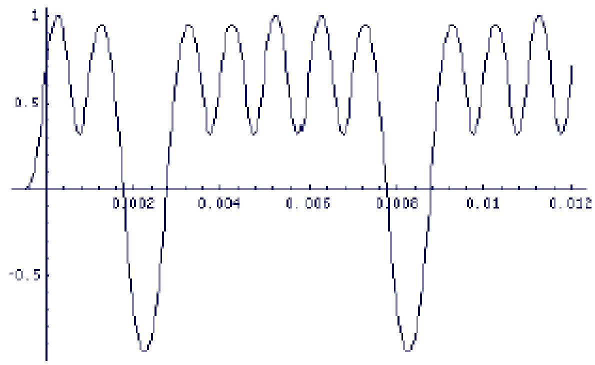


The I-baseband signal, i.e. the function I(t) as the second figure

Taking the Sine of c(t) produces the Q-baseband signal Q(t) i.e.

$$Q(t) = \mathrm{Sin}[\ c(t)\ ].$$

This function Q(t) is represented graphically below.



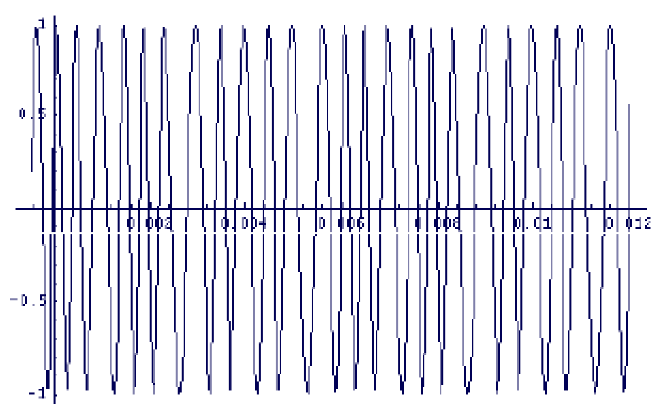
The Q-baseband signal, i.e. the function Q(t) as in the second figure.

These two functions I(t) and Q(t) are then passed through the I/Q modulator which leads to the output signal m(t) which can be written as

$$m(t) = \mathrm{Sin}(2\pi f_c\ t)\ I(t) + \mathrm{Cos}(2\pi f_c t)\ Q(t),$$

where f_c is the carrier frequency used as the oscillator in the second figure

The GMSK signal m(t) is represented



The GMSK modulated signal m(t) as in the second figure.